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(60) **References to other related national
documents:**

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(54) **WAVEGUIDE FILTER**

(57) The invention proposes a novel embodiment of a waveguide filter. The waveguide is made from foam 9 by molding. The foam is then coated with a conductive layer 10. The use of foam 9 makes it feasible to simplify production and to use less expensive materials. The invention also concerns the fabrication method.

Waveguide Filter

The invention relates to a waveguide filter, and more particularly to its physical makeup.

The proliferation of wireless data transmission applications has led to the design of systems utilizing increasingly high frequencies and offering broad transmission bands. Many filter technologies for carrying out filtering functions are known. Among the many types of filters, waveguide filters can be made to meet severe filtering requirements while at the same time offering reduced space consumption.

Waveguide filters can have a wide variety of shapes. In general, waveguide filters are composed of one or more cylindrically or rectangularly shaped cavities. The cavities can be coupled to one another by circular or rectangular irises that can be centered or eccentric. Metal or dielectric walls, shutters, or partitions can also be placed in the cavities according to the plane of the electric field. The diversity of arrangement of the various constituent elements can result in very complex shapes. In addition, the dimensions of the constituent elements of the filters decrease with high frequencies. For more information on the dimensioning of waveguide filters, one skilled in the art will refer to the work entitled *Microwave Filters, Impedance Matching Networks and Coupling Structures*, by G. Matthaei, L. Young and E.M.T. Jones.

The production of waveguide filters for high frequencies necessitates complex and costly machining operations that are not appropriate for consumer products.

In another connection, it is known to use foams to fill waveguide filters in order to modify the wave propagation medium, which makes it feasible to use smaller-sized waveguides.

The invention proposes a novel waveguide filter embodiment. The waveguide is made of foam by molding. The foam is then coated with a conductive layer. The invention is therefore a waveguide filter comprising a waveguide made of foam and a layer of conductive material deposited on said foam.

Molding waveguides eliminates complex machining of the waveguide. In order to have certain characteristics, however, the filter can comprise inserts passing through the foam, said inserts being at least partially covered by the conductive layer.

The invention also concerns a waveguide filter fabrication method comprising the following

steps:

- molding a foam into the shape of a waveguide,
- extracting the foam after solidification,
- depositing a layer of conductive material on the outer surfaces of the foam.

For some filters, inserts are placed in the foam before the layer of conductive material is deposited.

The invention will be better understood and other particularities and advantages will emerge upon a reading of the following description provided with reference to the annexed drawings, wherein:

Figs. 1 to 4 illustrate the various fabrication steps of a first type of filter according to the invention,

Figs. 5 to 8 illustrate the various fabrication steps of a second type of filter according to the invention.

The drawings in the present application are not done to scale for reasons of comprehension. In particular, dimensions have been stretched so that they can be visualized in a single figure.

Figure 1 shows the walls of a coupled-cavity waveguide filter. Four cylindrical cavities 1 to 4 are coupled by rectangular irises 5 placed in the middle of said cavities 1 to 4. Probes 6 and 7 serve to couple the filter to a high-frequency circuit, for example a microstrip-type circuit. The cavities 1 to 4 associated with probes 6 and 7 constitute two transition regions of a known type. In conventional technology, this type of filter is produced in at least two machined parts.

According to the invention, a two-part mold is fabricated, one part of which is depicted in Fig. 2. In addition to the shape of the waveguide, four openings 8 are made for filling the mold. In the example described, the two parts of the mold are identical, but it is naturally understood that the two parts can be different provided that they define the shape of the waveguide and one or more filling openings.

Once assembled, the mold is filled with a foam whose relative permittivity ϵ_r is close to 1. The

foam is preferably a polymethacrylate imide sold under the trademark Rohacelle 51. Once the mold has been hot-filled, it is allowed to cool and the waveguide produced in this manner is removed from the mold.

The waveguide 9 can then be deburred and coated with a conductive material. The conductive material is, for example, conductive paint deposited by spraying, as depicted in Fig. 3. Any paint that happens to be deposited on surfaces that are not to be coated can be removed by sanding or can be masked during the deposition of the conductive paint.

Figure 4 shows a completed filter in section. The waveguide 9 is coated with the conductive layer 10 except, at least, in the planes serving as transitions. The waveguide is glued to a substrate 11 that comprises, on the face contacting the waveguide, a metal layer 12 that forms a ground plane pierced by two slits. On the other face of the substrate, microstrip lines 13 and 14 are positioned opposite the cavities corresponding to the transitions. A person skilled in the art will observe that it is not necessary to cover with the conductive layer those portions of the waveguide that are in direct contact with the ground plane 12.

Other foams can be used. However, the choice of foam must take the relative permittivity of the foam into account. The more the permittivity deviates from 1, the greater the losses in the transmission chain. Such losses may or may not be acceptable, depending on the application. As an example, the following foams can be used:

Foam	ϵ_r
Polymethacrylate imide	1
Polyurethane	1.04

Other molding options are feasible, particularly injection or compression molding of the foam.

In addition, the metallization of the foam can be performed by wet deposition, i.e., chemical and or electrochemical dipping, for example in a copper solution compatible with the foam. It is also feasible to use vacuum metal deposition of the type of CVD (Chemical Vapor Deposition) or PVD (Physical Vapor Deposition). For such metal layer deposition, surface treatment of the foam can be provided after removal from the mold in order to facilitate the

adhesion of the metal layer.

Filters fabricated in this way do not require machining, only sanding at the most. The use of foam molding in high-volume production lowers production costs while permitting high dimensional accuracy. In addition, the waveguides can have complex shapes, but it is much simpler to mold the guide than to mold an element defining the guide.

As stated at the beginning of the application, the waveguide filters can comprise conductive or dielectric elements inside the waveguide.

The following example comprises additional metal inserts; Fig. 5 shows a foam waveguide 20 fabricated by molding. The waveguide 20 so produced defines three cylindrical cavities coupled by circular irises.

In Fig. 6, metal inserts 21 and 22 are placed in the central cavity of the waveguide 20. Two techniques can be used. A first technique is to drive the metal insert into the foam and have it make its own hole. A second technique is to make pilot holes slightly smaller than the insert and then drive the insert into the hole. Depending on the size and shape of the insert, one of these two techniques is selected. The inserts are held in position by the pressure exerted on them by the foam.

The metal inserts preferably project from the foam so as to be covered, at least in part, by the deposition of the conductive layer as shown in Fig. 7. The filter shown in section in Fig. 8 is then obtained. The conductive layer 23 ensures electrical contact with the metal inserts. Compared to a conventional filter, the insert placement operations are facilitated by the fact that the guide is made of foam, which is much easier to machine than metal.

One advantage of fabricating a waveguide filter according to the invention is the temperature stability of the filter. Waveguide filters are exposed to outdoor temperature variations, i.e., to temperatures ranging from -20°C to +80°C. Since the thermal expansion coefficient of foam is generally lower than that of the metals used in conventional filters, the filter produced is perfectly well suited for applications utilizing millimetric waves.

Another advantage is the cost of the material. Foam costs much less than metal alloys having a low expansion coefficient.

CLAIMS

1. A waveguide filter comprising a waveguide made of foam (9) and a layer (10) of conductive material deposited on said foam (9).

2. The filter according to claim 1, characterized in that said foam (9) is of polymethacrylate imide.

3. The filter according to claim 1, characterized in that said foam (9) is polyurethane foam.

4. The filter according to one of claims 1 to 3, characterized in that said conductive material (10) is a conductive paint.

5. The filter according to one of claims 1 to 4, characterized in that it comprises inserts (21, 22) passing through said foam, said inserts being at least partially covered by said conductive layer.

6. A waveguide filter fabrication method comprising the following steps:

- molding a foam in the shape of a waveguide,
- extracting said foam after solidification,
- depositing a layer of conductive material on the outer surfaces of said foam.

7. The method according to claim 6, characterized in that inserts are placed in said foam prior to the deposition of said layer of conductive material.

8. The method according to either of claims 6 and 7, characterized in that said foam is of polymethacrylate imide.

9. The method according to either of claims 6 and 7, characterized in that said foam is a polyurethane foam.

10. The method according to one of claims 6 to 9, characterized in that said layer of conductive material is a conductive paint.

PRELIMINARY SEARCH REPORT
 established on the basis of the last claim
 filed before the search was started

National Application No.
 FA 607734
 FR 0111971

Relevant Documents

Category	Identification of Documents with specification, where required of critical parts	Re Claim	Class assigned by INPI
X	HAREL J P ET AL: "Foam technology for integration of millimetre-wave 3D functions" ELECTRONICS LETTERS, IEE STEVENAGE, GB, Vol. 35, No. 21 14 October 1999 (1999-10-14), pages 1853-1854, XP006012853 ISSN: 0013-5194 * page 1853, left column, line 1 - right column, line 11; figures 1, 2; table 1	1, 2, 4, 6 8,10	H01P1/207 H01P11/00
Y	-----	3, 5, 7, 9	
Y	GB 1 230 147 A (TELEFUNKEN PATENTVERWER- TUNGSGESELLSCHAFT M.B.H.) 28 April 1971 (1971-04-28) * the entire document *	3, 9	
Y	US 6 107 901 A (BROWN KENNETH W ET AL) 22 August 2000 (2000-08-22) * column 2, line 41-60 * * column 3, line 55 - column 4, line 1; figures 4B, 5, 6 *	5, 7	
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A	"HOHLLEITER AUS DER SPRITZPISTOLE" ELEKTRONIK., VOL. 33, No. 18, September 1984 (1984-09), page 98 XP002197118 FRANZIS VERLAG GMBH, MUNCHEN, DE ISSN: 0013-5658 * the entire document *	1	H01P
A	EP 0 859 423 A (MURATA MANUFACTURING CO) 19 August 1998 (1998-08-19) * column 4, line 58 - column 6, line 19; figures 1-5* -----	1	

Search completed
23 April 2002

Examiner
Den Otter, A

Category of cited documents

- X particularly relevant by itself
 Y particularly relevant in combination with another document of the same category
 A background technology
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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON FRENCH PATENT APPLICATION NO.**

FR 111971 FA 607734

This annex lists the patent family members relating to the patent document cited in the above-mentioned international search report.

The members are as contained in the European Patent Office EDP of 23-04-2002

The European Patent Office is in no way liable for the particulars which are merely given for the purpose of information.

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US 6107901	A	22-08-2000	None	
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